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Feasibility study of a muon polarization monitor: Monte-Carlo simulation of muon detection and decay position reconstruction

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In this project, we proposed a feasibility study of muon polarization measurement using a self-designed detector to monitor the muon beam's polarization in J-PARC. The detector utilizes the asymmetric angular distribution of positrons decayed from polarized muons to measure polarization indirectly. Monte-Carlo simulation is applied to optimize the structure of the detector and estimate its performance, such as efficiency and accuracy. The whole program is divided into 3 phases. In the first two phases, we use atmospheric muon to study the feasibility and performance of our detector. In phase 3, a simulation of the muon beam at J-PARC is conducted.

The detector is designed to have scintillator bars and a copper target of 10 mm thickness, which stops muon and helps measure the polarization. In phase 1, four layers of scintillators are used to detect atmospheric muons and positrons generated by muon decay to analyze angular distribution. Two energy cuts are applied to select muon decayed in the copper target and to distinguish positrons from other particles. An overall efficiency of 0.2% can be obtained. After correcting errors, the relationship between asymmetry and muon polarization shows good linearity. In phases 2 and 3, detectors are installed at four corners. Each corner has three layers, improving accuracy and enabling the reconstruction of the position tracks. The spatial resolution is estimated to be around 20 mm.

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